

Activity 9-1

The Nature of Organic Compounds

For each of the following paragraphs, numbered 1-6, choose words from the word list to fill in the blanks in that paragraph. Some lists group words that have contrasting meanings.

1. Origin and scope of organic chemistry

Word List

| | | |
|-----------|-----------|-----------|
| bonds | four | organic |
| carbon | living | petroleum |
| compounds | molecules | produced |

Organic chemistry is the branch of chemistry that deals with the reactions and properties of the compounds of the element carbon. In the early days, the term *organic* was applied to compounds found only in living organisms. It was widely believed that organic compounds could be produced only by plants or animals. However, in 1828 urea was produced from ammonium chloride and silver cyanate by Friedrich Wöhler as the first organic compounds to be synthesized in the laboratory. Earlier beliefs about the nature of organic compounds were discarded and except for a few kinds of compounds such as the oxides of carbon and the carbonates, all carbon compounds came to be considered as organic.

Today, organic chemistry is the largest and most important branch of chemistry. The work of most chemists deals with organic compounds. A very large number of organic compounds of many different types are known. This diversity exists because each carbon atom can form four covalent bonds with atoms of other elements and, more importantly, with other carbon atoms. There appears to be no upper limit to the number of carbon atoms that can be bonded together to form very large molecules.

2. Characteristics of organic compounds

Word List

| | | |
|------------------------------|-----------------------|----------|
| nonelectrolytes/electrolytes | positively/negatively | soluble |
| nonpolar/polar | organic | solvents |

Molecules of organic compounds are generally nonpolar and tend to dissolve in nonpolar solvents. Most of these molecules are not very soluble in polar solvents such as water. However, some molecules such as ethyl alcohol and acetic acid are sufficiently polar to be soluble in water. Compared to the electrolytic properties of most inorganic compounds, most organic molecules are generally nonelectrolytes.

3. Boiling points and melting points of organic compounds

Word List

| | |
|----------------|----------------------|
| high/low | solids/liquids/gases |
| intermolecular | strong/weak |
| polar/nonpolar | |

The molecules of some organic compounds are nonpolar or only slightly polar. Because of this, the intermolecular forces are weak. In the laboratory this characteristic is observed as relatively low melting points, low boiling points, low heats of vaporization, and high vapor pressures. At ordinary temperatures, most inorganic substances are generally solids, while many organic substances are liquids or gases.

4. The reaction rate of organic reactions

Word List

| | | |
|----------------|---------------|-------------------|
| activated | faster/slower | ions |
| between/within | forces | rapidly/slowly |
| covalent/ionic | high/low | organic/inorganic |

There is strong covalent bonding between atoms within organic molecules. In order to undergo chemical changes a significant amount of rearrangement of bonds is required. This, in turn, requires a high energy of activation. For these reasons, activated complexes, the intermediate structures in reaction mechanisms do not form readily. Thus, organic reactions take place more slowly than inorganic reactions. Inorganic reactions proceed at faster rates because the forces of attraction between positive and negative ions increase the likelihood of forming the activated complex.

5. Bonding in organic compounds

Word List

angle
metals/nonmetals

molecular/ionic
share/transfer

tetrahedron
four

In molecules of organic compounds, each carbon atom forms the equivalent of four bonds to other carbon atoms as well as other kinds of atoms. The four valence electrons of carbon can form four single covalent bonds. These bonds are directed toward the four corners of a regular tetrahedron. The bond angle between any two of these bonds is $109^{\circ}28'$. This angle is sometimes called the tetrahedral angle. Adjacent carbon atoms can share one, two, or three pairs of electrons. Carbon atoms can also share one, two, or three pairs of electrons with atoms of other elements, usually other nonmetals. The forces of attraction between organic molecules cause them to form molecular solids.

6. Classification of organic compounds

Word List

decreases
chemical
homologous
increases

increment
intermolecular
number
structures

Organic compounds can be classified into groups having similar molecular structures and similar chemical properties. Such groups are called homologous series. Each member of a homologous series differs from the preceding member by a common increment. As members of a series increase in size of molecules and number of electrons, the strength of the intermolecular forces, primarily van der Waals forces, increases. As the strength of these intermolecular forces increases, boiling point increases, melting point increases, and vapor pressure decreases.

Activity 9-2

Hydrocarbons

- What are the only two elements in a hydrocarbon? hydrogen and carbon
- What is an aliphatic hydrocarbon? hydrocarbon with open chain structure – either straight or branched
- What is an aromatic hydrocarbon? any hydrocarbon that has at least one benzene ring
- What is a homologous series of hydrocarbons? a series in which each member has the same general formula
- How does the structural formula of one member of a homologous series of hydrocarbons differ from the next lower member? the higher member has an additional CH₂ group (called the increment)

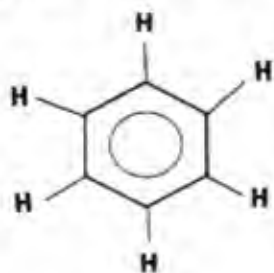
Aliphatic hydrocarbons

Complete the following table to show the relationship between three homologous series of aliphatic hydrocarbons.

| | | Alkanes | Alkenes | Alkynes |
|-----|--|---|---|--|
| 6. | Other name(s) for series | paraffins methane series | olefins ethylene series | acetylene series |
| 7. | General formula | C_nH_{2n+2} | C_nH_{2n} | C_nH_{2n-2} |
| 8. | Series increment | CH ₂ | CH ₂ | CH ₂ |
| 9. | Structural formula for characteristic carbon-carbon bond | $\begin{array}{c} & \\ -C & -C- \\ & \end{array}$ | $>C=C<$ | $-C\equiv C-$ |
| 10. | Suffix for name | -ane | -ene | -yne |
| | Names and molecular formulas up to the 5-carbon member | (1) methane CH ₄ (2) ethane C ₂ H ₆ (3) propane C ₃ H ₈ (4) butane C ₄ H ₁₀ (5) pentane C ₅ H ₁₂ | (2) ethene C ₂ H ₄ (3) propene C ₃ H ₆ (4) butene C ₄ H ₈ (5) pentene C ₅ H ₁₀ | (2) ethyne C ₂ H ₂ (3) propyne C ₃ H ₄ (4) butyne C ₄ H ₆ (5) pentyne C ₅ H ₈ |
| 11. | Structural formula for 3-carbon member | $\begin{array}{c} & & \\ -C & -C & -C- \\ & & \end{array}$ | $\begin{array}{c} & & \\ -C & =C & -C- \\ & & \end{array}$ | $\begin{array}{c} \\ -C\equiv C-C- \\ \end{array}$ |

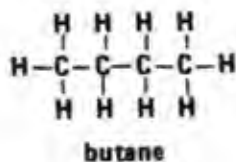
Aromatic hydrocarbons

12. What is the general formula for the benzene series? C_nH_{2n-6}
13. What are the names and formulas for the first two members of the benzene series?
 C_6H_6 – benzene; C_7H_8 or $C_6H_5CH_3$ – toluene
14. Members of the benzene series are aromatic (aliphatic/aromatic) hydrocarbons.
15. Why are members of the benzene series considered to be hydrocarbons? They contain only the elements carbon and hydrogen.
16. Draw a structural formula for benzene that shows its bonding structure as an average of single and double bonds.

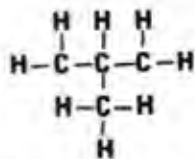


Isomers

17. What are isomers? Compounds having the same molecular formula but different structural formulas, giving them different physical and chemical properties.
18. The simplest alkane that has isomers is butane. What is the molecular formula for butane?
 C_4H_{10}
19. Draw structural formulas for the two isomers of butane. Label each with its IUPAC name.

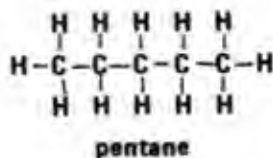


butane

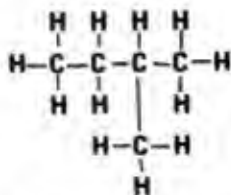


2-methylpropane

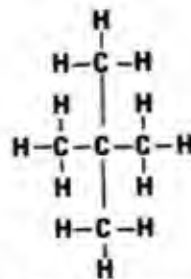
20. Draw structural formulas for the three isomers of pentane. Label each with its IUPAC name.



pentane



2-methylbutane



2,2-dimethylpropane

Petroleum

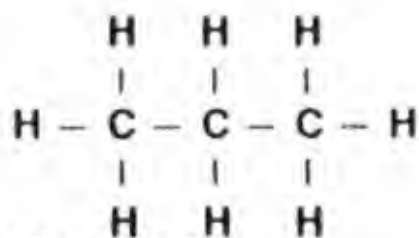
21. What is petroleum? a mixture consisting primarily of saturated hydrocarbons; it may also contain certain
unsaturated hydrocarbons, aromatics, and sulfur and nitrogen derivatives
22. List six kinds of chemical products obtained from petroleum. gasoline,
kerosene, diesel fuel, mineral oil,
propane, lubricating oil, home heating fuel, petroleum jelly, etc.
23. What properties permit the use of fractional distillation as a means to separate petroleum into useful components? The different useful components have different boiling points. As the temperature of
the mixture reaches the b.p. of a particular component, that component leaves the mixture as a gas and is condensed and
collected.
24. Describe the process of cracking as used in petroleum refining. A catalyst is used to break large
molecules down into smaller molecules with lower boiling points.

NAMING HYDROCARBONS

Name _____

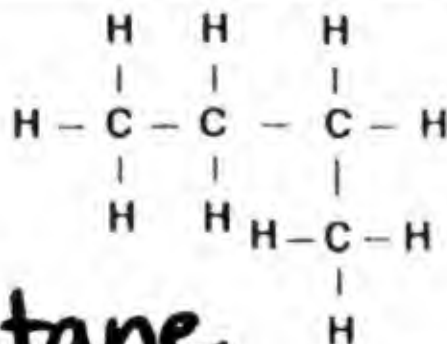
Name the compounds below according to the IUPAC naming system

1.



propane

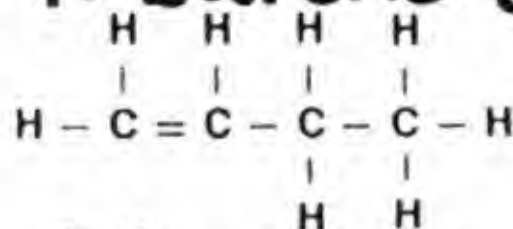
5.



butane

2.

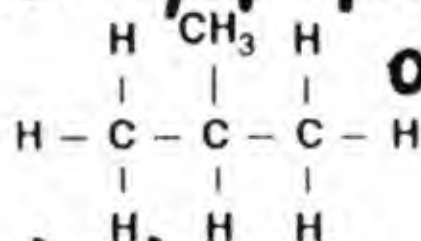
n-butene or



1-butene

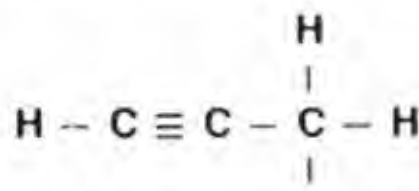
6.

Methyl propane or



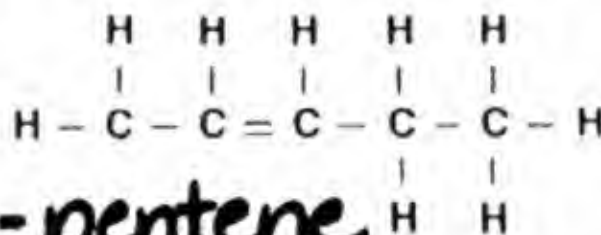
isobutane

3.



propyne

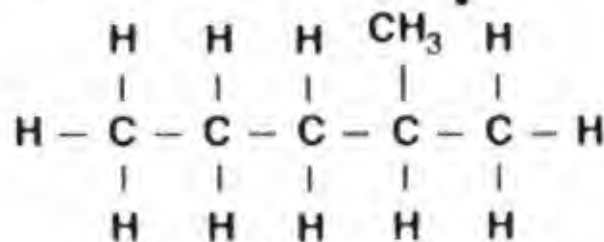
7.



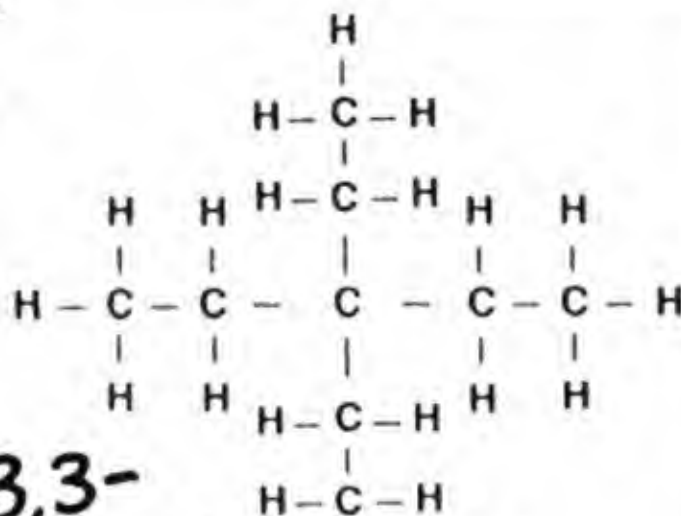
2-pentene

4.

2-methyl pentane



8.



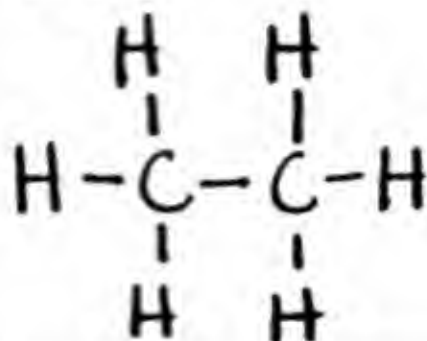
3,3-diethylpentane

STRUCTURE OF HYDROCARBONS

Name _____

Draw the structure of the compounds below.

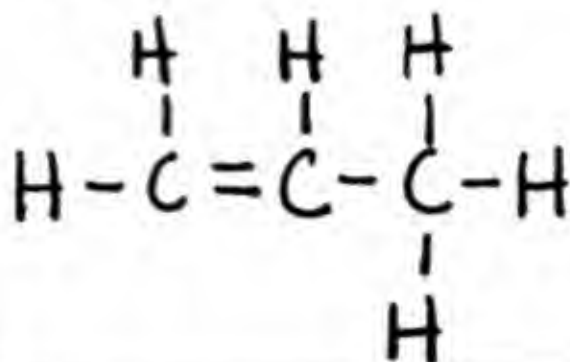
1. ethane



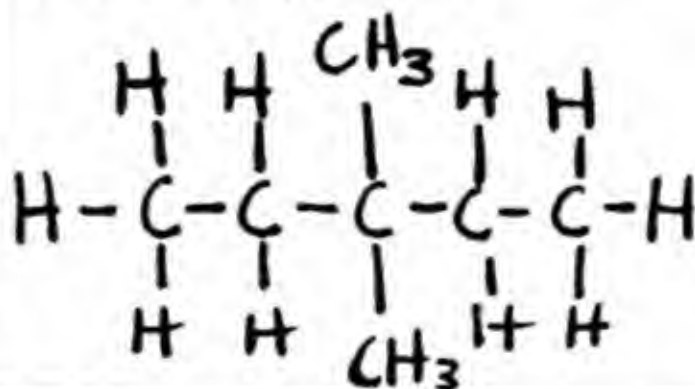
5. ethyne



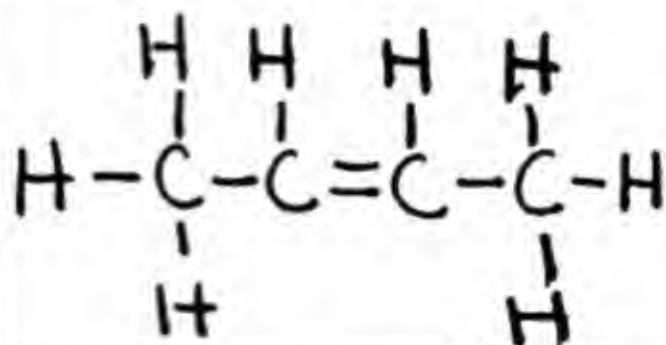
2. propene



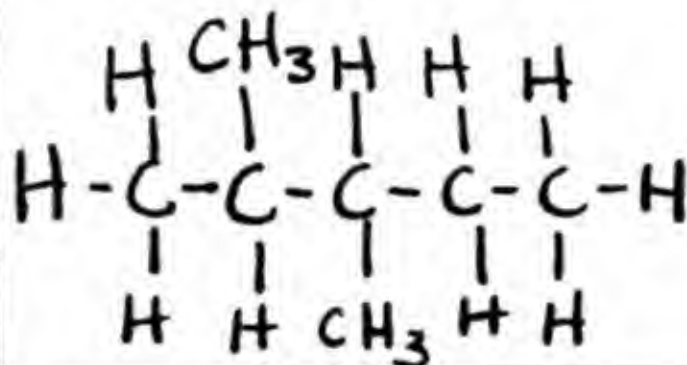
6. 3,3-dimethyl pentane



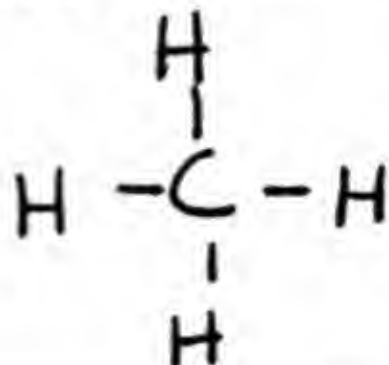
3. 2-butene



7. 2,3-dimethyl pentane



4. methane



8. n-butyne

